Solar Cookers
Effective Tools for 3-D Learning

Presented at the National Science Teachers Association (NSTA) Conference in Atlanta, Georgia

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by

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&

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PART 1

Mary Buchenic

Global Development Solutions

Our mission is to connect
and support
those working at the grass-roots level
to solve quality of life issues
in ways consistent
with the principles and goals of GDS.

Do good well.
GDSnonprofit.org

The Solar Sisters Project
GDSnonprofit

**Working to promote
solar cookers
as tools for education,
wellness,
economic empowerment,
and ecosystem recovery.**

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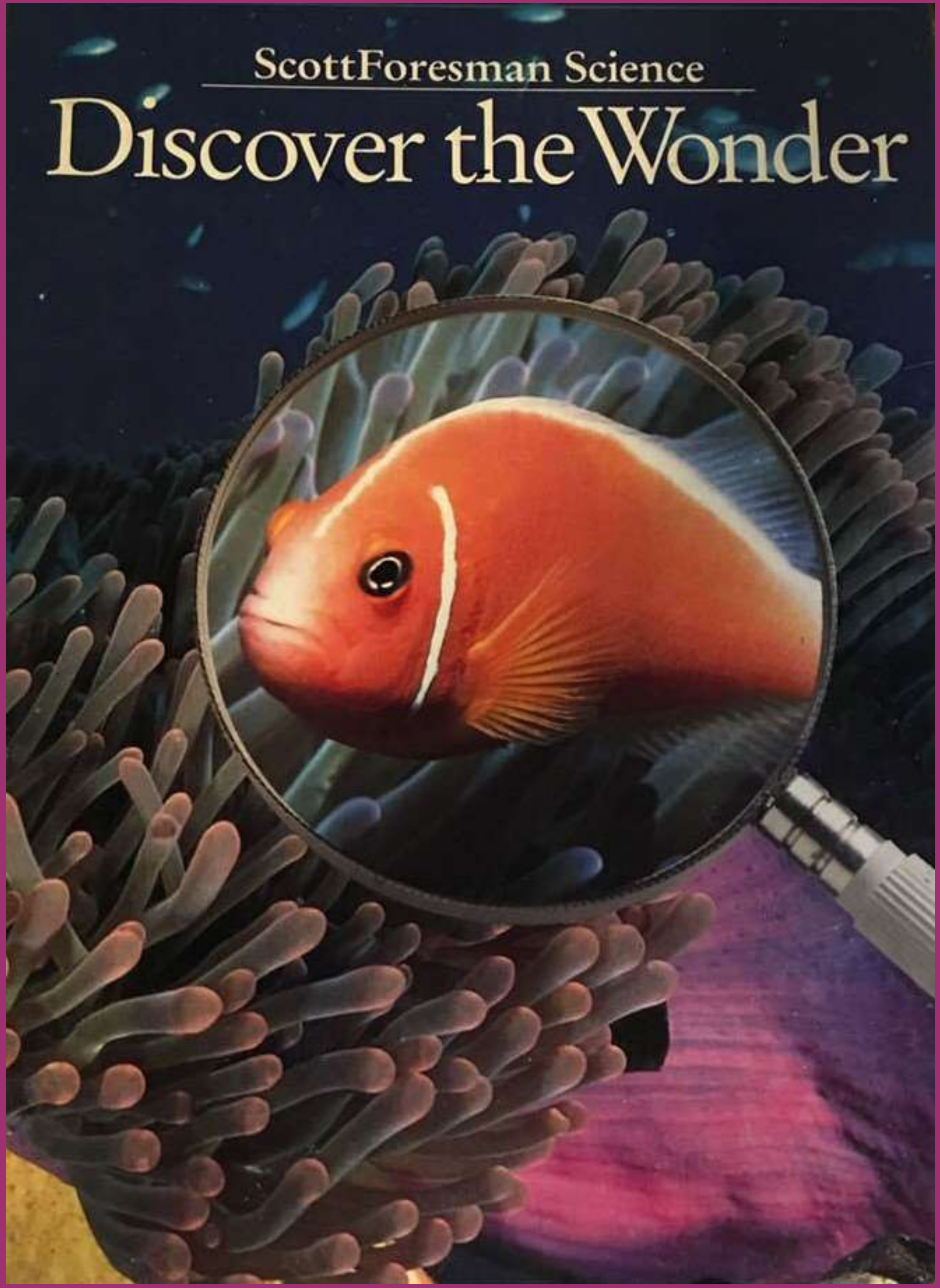
Visit
gdsnonprofit.org/solar-cooker-education
for session slides, solar cooking lessons,
experiments, & patterns,
and to learn about our mission work.

SCI SOLAR COOKERS INTERNATIONAL

Mission
To spread solar thermal cooking technology to benefit people and environments.

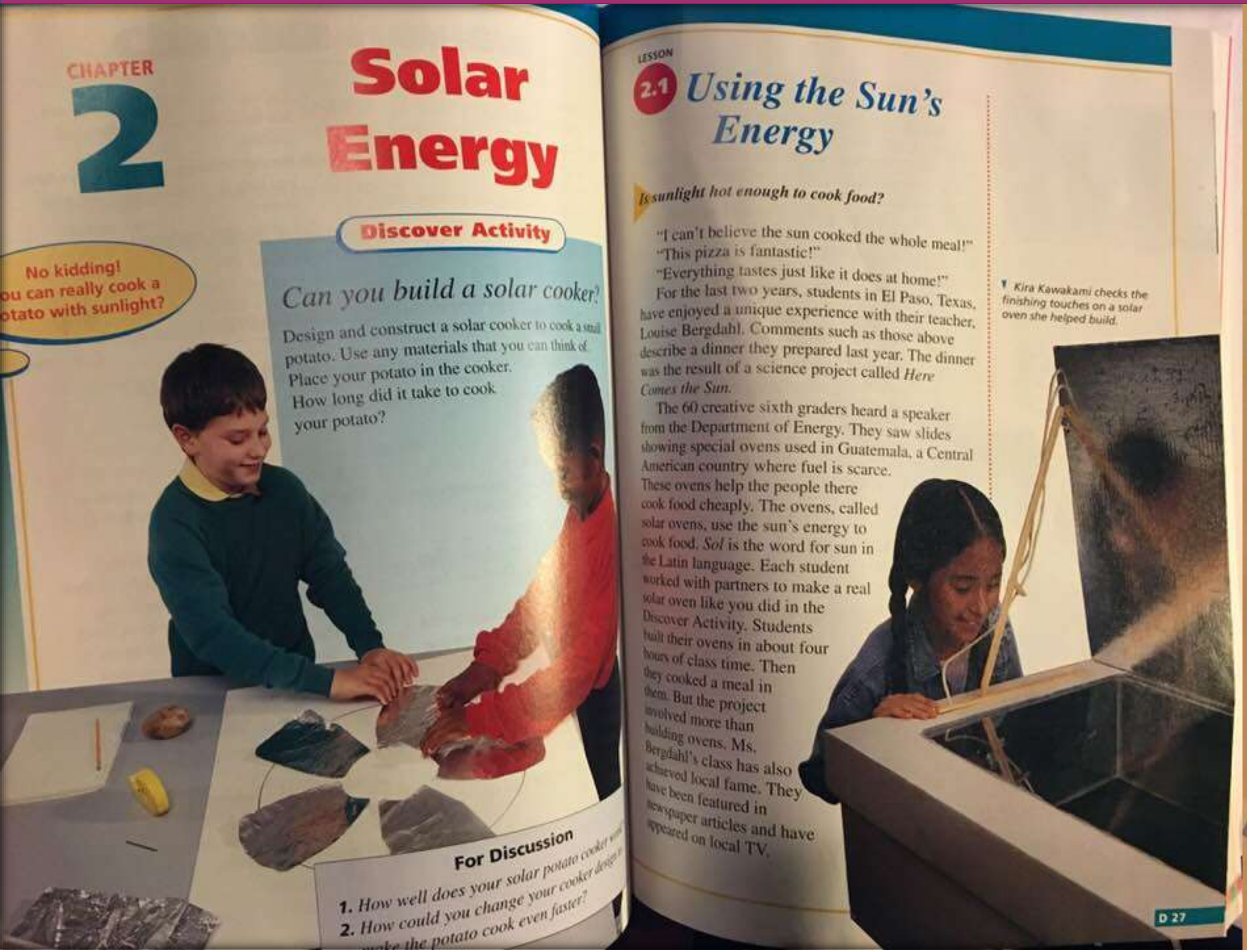
solarcookers.org
Visit solarcooking.wikia.com
for great educational
information on the solar
cooking movement

How I Discovered the Wonder of Solar Cooking in 1996



FOUR PAGES of a new Science Textbook!

1 **2** **3** **4**



CHAPTER 2

Solar Energy

Discover Activity

No kidding! ...ou can really cook a ...tato with sunlight?

Can you build a solar cooker?

Design and construct a solar cooker to cook a small potato. Use any materials that you can think of. Place your potato in the cooker. How long did it take to cook your potato?

For Discussion

1. How well does your solar potato cooker w...
2. How could you change your cooker desig... ...make the potato cook even faster?

LESSON 2.1

Using the Sun's Energy

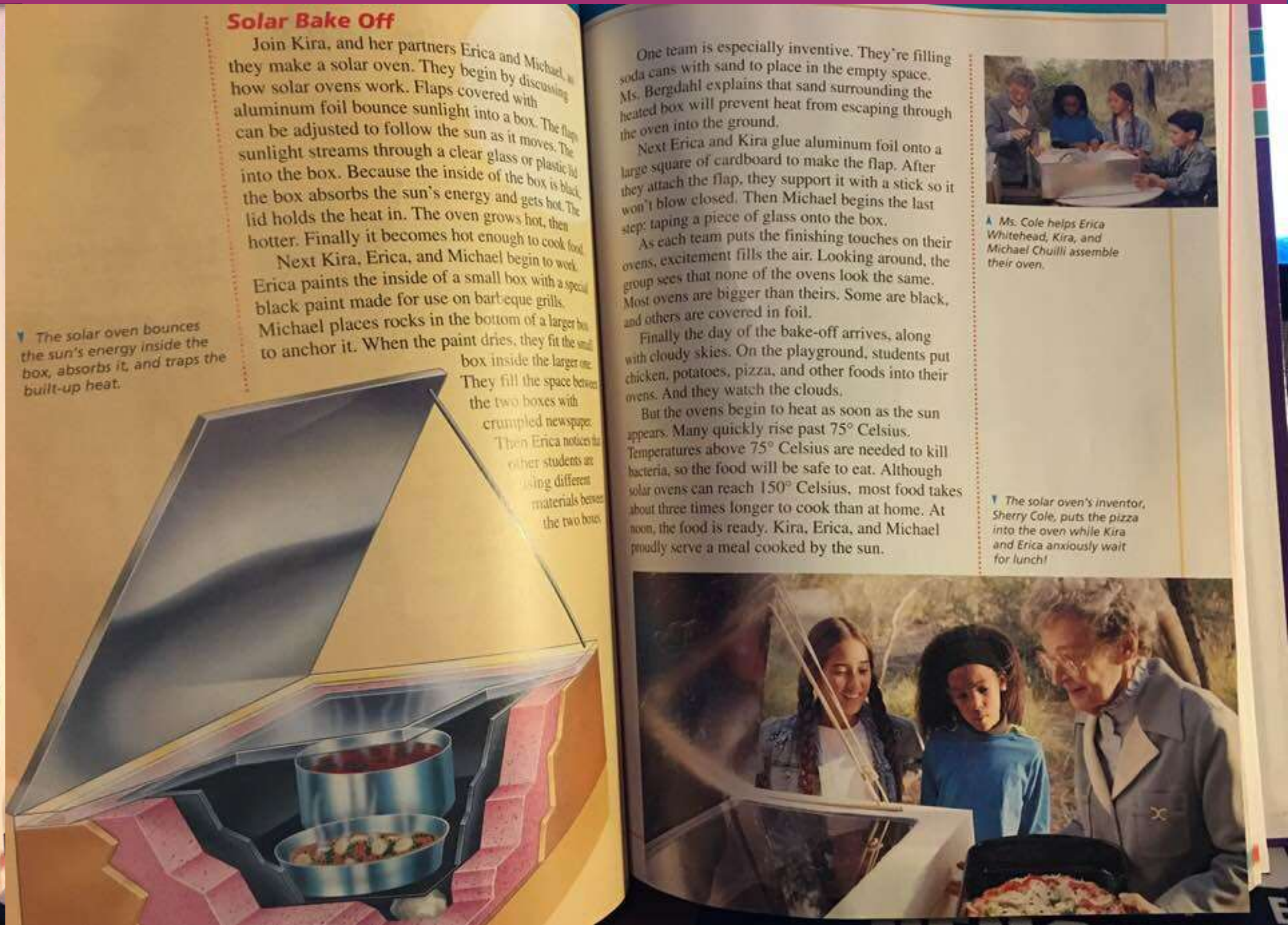
Is sunlight hot enough to cook food?

"I can't believe the sun cooked the whole meal!"
"This pizza is fantastic!"
"Everything tastes just like it does at home!"

For the last two years, students in El Paso, Texas, have enjoyed a unique experience with their teacher, Louise Bergdahl. Comments such as those above describe a dinner they prepared last year. The dinner was the result of a science project called *Here Comes the Sun.*

The 60 creative sixth graders heard a speaker from the Department of Energy. They saw slides showing special ovens used in Guatemala, a Central American country where fuel is scarce. These ovens help the people there cook food cheaply. The ovens, called solar ovens, use the sun's energy to cook food. *Sol* is the word for sun in the Latin language. Each student worked with partners to make a real solar oven like you did in the Discover Activity. Students built their ovens in about four hours of class time. Then they cooked a meal in them. But the project involved more than building ovens. Ms. Bergdahl's class has also achieved local fame. They have been featured in newspaper articles and have appeared on local TV.

Kira Kawakami checks the finishing touches on a solar oven she helped build.



Solar Bake Off

Join Kira, and her partners Erica and Michael, as they make a solar oven. They begin by discussing how solar ovens work. Flaps covered with aluminum foil bounce sunlight into a box. The flaps can be adjusted to follow the sun as it moves. The sunlight streams through a clear glass or plastic lid into the box. Because the inside of the box is black, the box absorbs the sun's energy and gets hot. The lid holds the heat in. The oven grows hot, then hotter. Finally it becomes hot enough to cook food.

Next Kira, Erica, and Michael begin to work. Erica paints the inside of a small box with a special black paint made for use on barbeque grills. Michael places rocks in the bottom of a larger box to anchor it. When the paint dries, they fit the small box inside the larger one. They fill the space between the two boxes with crumpled newspaper. Then Erica notices that other students are using different materials between the two boxes.

The solar oven bounces the sun's energy inside the box, absorbs it, and traps the built-up heat.

One team is especially inventive. They're filling soda cans with sand to place in the empty space. Ms. Bergdahl explains that sand surrounding the heated box will prevent heat from escaping through the oven into the ground.

Next Erica and Kira glue aluminum foil onto a large square of cardboard to make the flap. After they attach the flap, they support it with a stick so it won't blow closed. Then Michael begins the last step: taping a piece of glass onto the box.

As each team puts the finishing touches on their ovens, excitement fills the air. Looking around, the group sees that none of the ovens look the same. Most ovens are bigger than theirs. Some are black, and others are covered in foil.

Finally the day of the bake-off arrives, along with cloudy skies. On the playground, students put chicken, potatoes, pizza, and other foods into their ovens. And they watch the clouds.

But the ovens begin to heat as soon as the sun appears. Many quickly rise past 75° Celsius. Temperatures above 75° Celsius are needed to kill bacteria, so the food will be safe to eat. Although solar ovens can reach 150° Celsius, most food takes about three times longer to cook than at home. At noon, the food is ready. Kira, Erica, and Michael proudly serve a meal cooked by the sun.

Ms. Cole helps Erica Whitehead, Kira, and Michael Chuilli assemble their oven.

The solar oven's inventor, Sherry Cole, puts the pizza into the oven while Kira and Erica anxiously wait for lunch!

15 YEARS

100 students per year = 1,500 students

RESEARCHED

DESIGNED

BUILT

TESTED

their own unique solar ovens.

What I loved about using Solar Cooking as the theme for 3-Dimensional and Cross Curricular learning.

Many differentiated learning opportunities.

Reinforces understanding of core ideas.

Students experience how knowledge and skills can be applied.

Provides opportunity for intercultural understanding.

There's food involved.

Concepts transfer more readily.

Eliminates discipline issues.

Promotes deeper understanding of content.

Motivates.

Develops better relationships with co-workers.

Topic lends itself to several disciplines.

Students see tangible results of their planning, designing and constructing.

Students understand how technology can benefit people.

Work cooperatively with co-workers in a supportive manner.

Students witness teachers cooperating and can use this example for their own work ethic.

Challenges creativity.

Students understand the benefit of collaboration.

Opportunity to develop altruism.

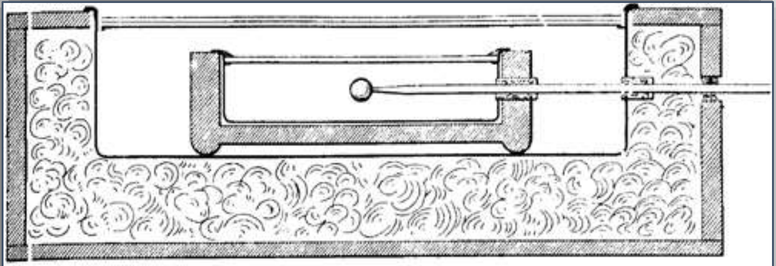
Gives rise to authentic purpose for learning.

Students recall the experience years later.

Multiple applications.

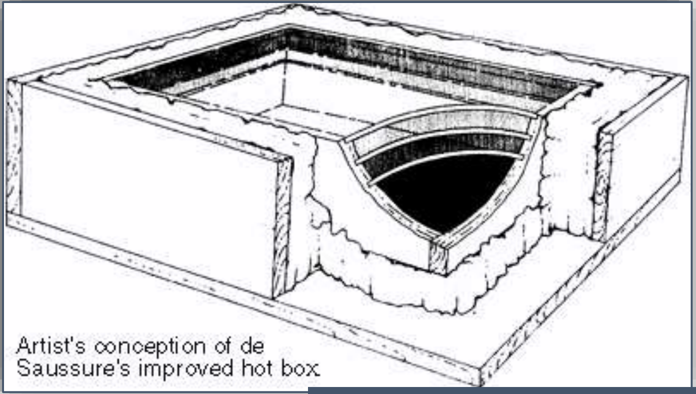
Basic Introduction to Solar Cooking

Sample of Early Solar Ovens



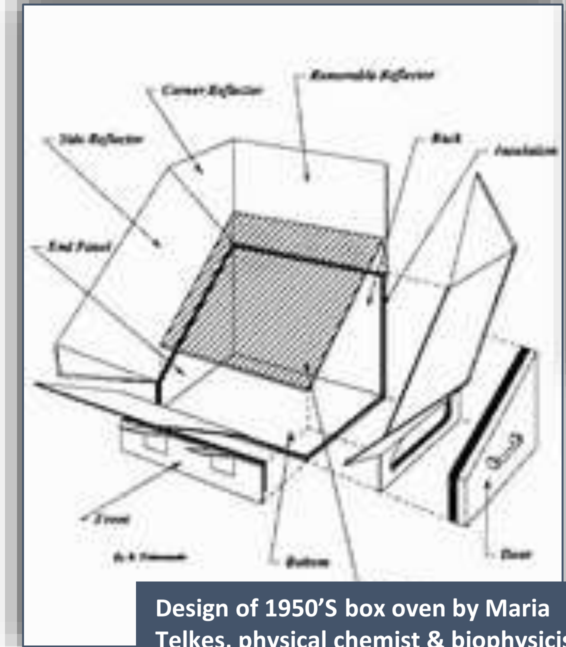
Cross-section of Langley's hot box, which was similar to de Saussure's later models. A thermomether penetrating the walls at right was used to measure the air temperature inside the inner box.

Samuel Langley 1884



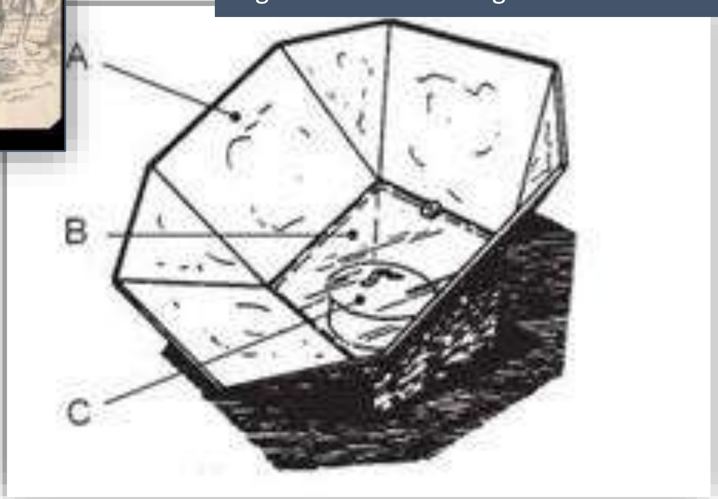
Artist's conception of de Saussure's improved hot box

Horace de Saussure's hot box - 1767



Design of 1950'S box oven by Maria Telkes, physical chemist & biophysicist. Source: Arizona State University

W Adams 1878 Bombay, India
Eight mirrors reflect light into wooden box.



SolarCooking.org

EnergyProfessionalSymposium.com

Transform sunlight to heat energy. Retain it for cooking.
SUNLIGHT IS YOUR FUEL

D irect extra sunlight

One or more shiny surfaces reflect extra sunlight onto the cooking pan, increasing its heat potential.

A bsorb light and convert to heat

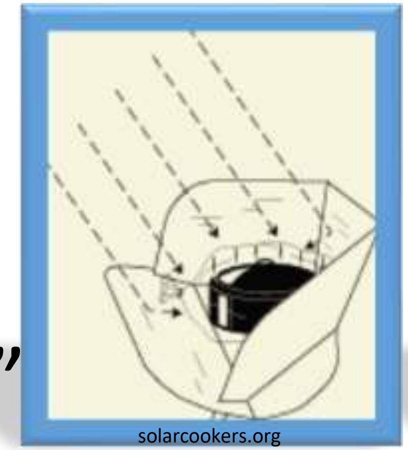
Dark surfaces get very hot in sunlight, whereas light surfaces don't. Food cooks best in dark, shallow, thin metal pots with dark, tight-fitting lids to hold in heat and moisture.

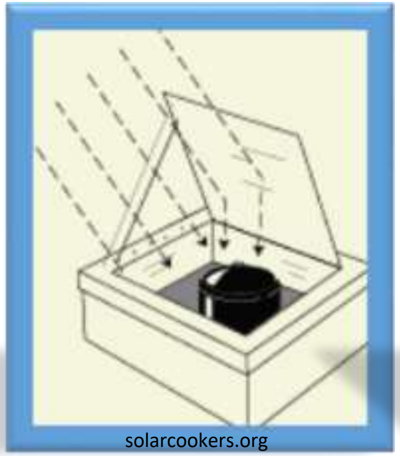
R etain heat

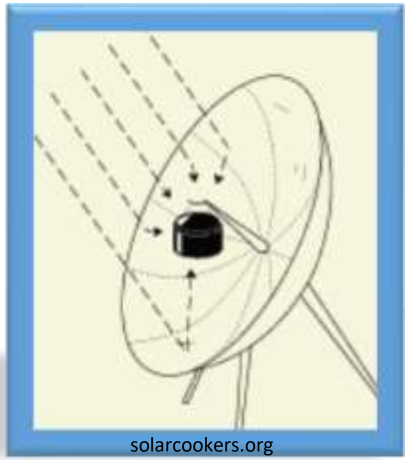
A transparent heat trap around the dark pot lets in sunlight, but won't let the heat out. For panel ovens, use a clear oven bag or inverted glass bowls. For box oven, use insulation and a transparent window.

E at and enjoy your solar cooked food.

Eat and enjoy healthy and nutritious food cooked with the cleanest burning fuel there is.







"DARE to cook with sunshine!"

TheSolarSisters, GDSnonprofit,org

BOX OVEN

- Box ovens use reflectors to direct sunlight into the cooking space.
- The oven interior includes one or more black walls.
- The oven is well insulated to retain heat.
- Box ovens can reach temperatures of 325° F in a direct sun.

BOX OVEN

Gluten Free
Lemon Cake

John Buchenic, USA

PANEL OVEN

- Uses reflective material to direct sunlight into a cooking space.
- Cooking space holds a black cooking pan that absorbs sunlight and converts it to heat.
- Heat is retained by using a transparent enclosure such as an oven bag or inverted pyrex bowls.
- Approximate Range: 200° F – 325° F

PANEL OVEN

Steamed Rice

Wade Steene, USA

PANEL OVEN

Baked Pork Chop

Mary Buchenic, USA

EVACUATED TUBE

- Double layers of glass with no air in between.
- Food is placed inside the tube.
- The dark interior part of the tube absorbs the light and converts it to heat.
- The evacuated space between the glass layers prevents heat loss.
- Approximate range 250° F – 400° F

EVACUATED TUBE

Chicken

Mary Buchenic, USA

EVACUATED TUBE

Bread

Mary Buchenic, USA

PARABOLIC OVEN

- Concentrates many rays of light onto a black cooking pan.
- The amount of concentrated light can result in heating the food similar to placing it on a burner.
- Deep parabolics spread the concentrated light around the cooking pan.
- Shallow parabolics focus light more tightly.

PARABOLIC

Frying Food

Janos Baglyios, Hungary

PARABOLIC

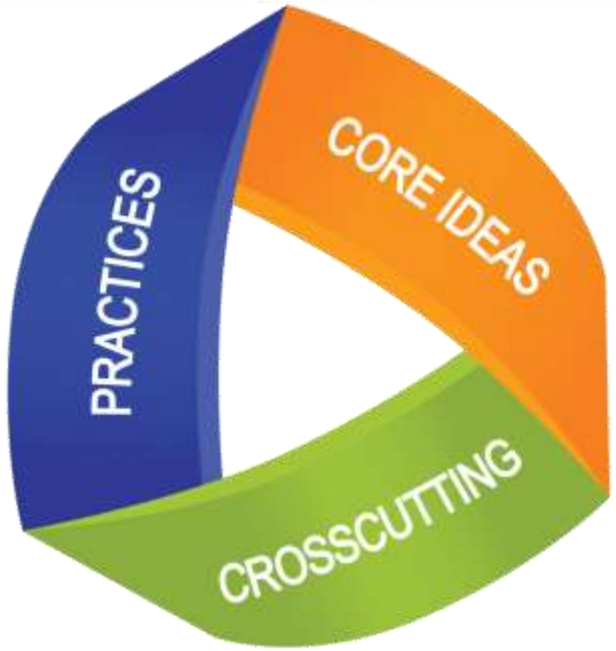
Popcorn

John Buchenic, USA

SAFETY

- Do not look directly at the sun.
- Do not look into the glare of the reflectors.
- Use oven mitts to handle hot pots and pans.
- Use a thermometer to test for safe internal temperature of meats.
- Keep hands and food preparation areas clean.
- Be aware of allergies when preparing food.
- Solar cooking requires sunshine. Do not attempt to cook on a cloudy day.

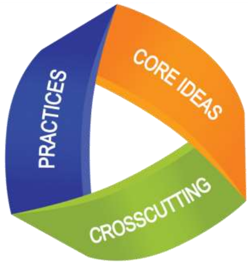
Solar Cookers are 3-Dimensional!



The Next Generation Science Standards were released in 2013.

"Lessons and units aligned to the standards should be three-dimensional; that is, they should allow students to actively engage with the practices and apply the crosscutting concepts to deepen their understanding of core ideas across science disciplines." *nextgenscience.org*

Solar Cooker themed lessons align easily with the concept of three dimensional learning.



Dimension 1
DISCIPLINARY CORE IDEAS

Key ideas in science that build on each other

GROUPED BY FOUR DOMAINS

Physical Science
Life Science
Earth and Space Science
Engineering, Technology & Application

nextgenscience.org

Rank the domains from most relevant to least in relation to a solar cooking themed lesson.

Dimension 2
CROSSCUTTING CONCEPTS

Connections across the four domains

SEVEN CONCEPTS

Patterns
Cause and effect
Scale, proportion, and quantity
Systems and system models
Energy and matter
Structure and function
Stability and change

nextgenscience.org

How can the crosscutting concepts be explored through a solar cooking themed lesson?

Dimension 3
PRACTICES

Investigate the natural world. Design and build systems.

SCIENCE AND ENGINEERING PRACTICES

Ask questions and define problems

Develop and use models

Plan and carry out investigations

Analyze and interpret data

Use math and computational thinking

Construct explanations and design solutions

Base arguments from evidence

Communicate information

nextgenscience.org

How can a solar cooking themed lesson reinforce every science and engineering practice?

Disciplinary Core Ideas
Crosscutting Concepts
Practices

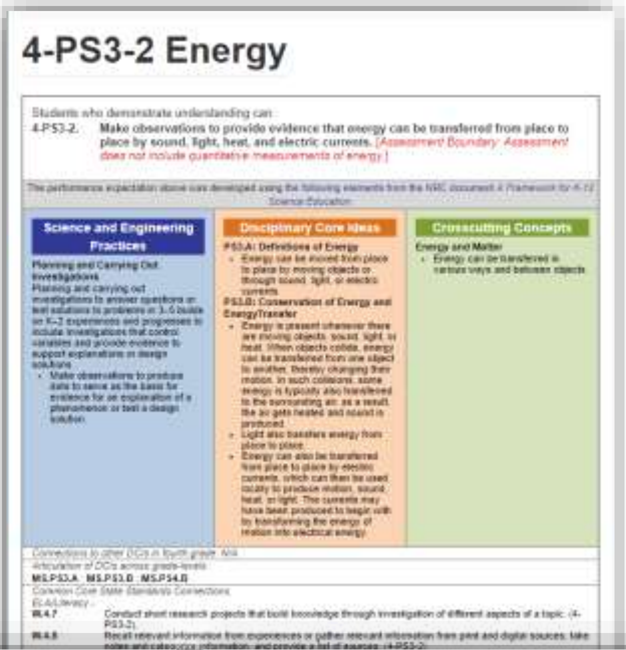
Disciplinary Core Ideas

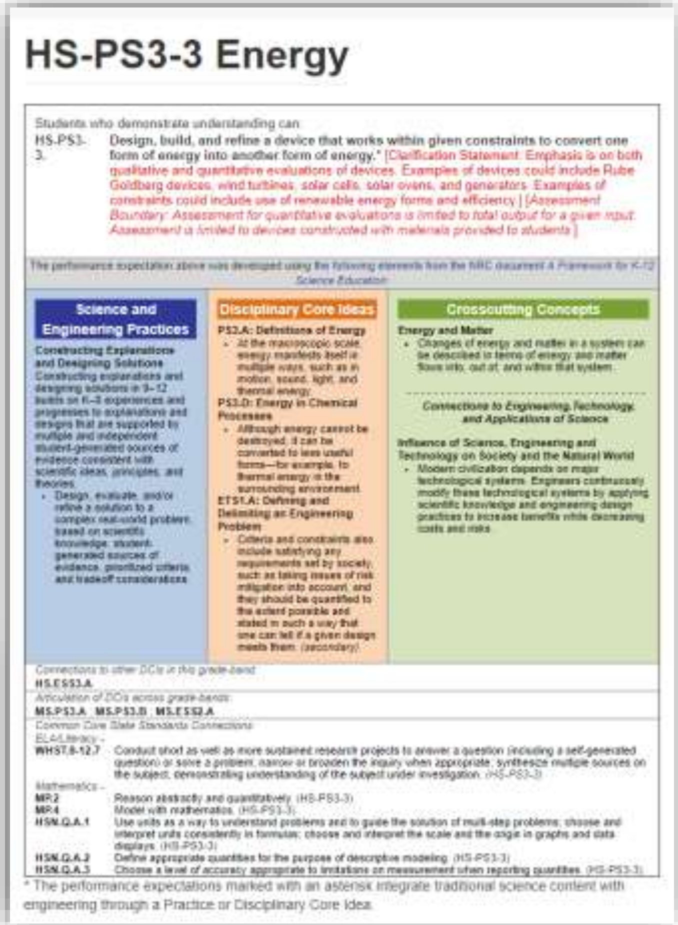
Physical Science
PS 1: Matter & its interactions
PS 2: Motion & stability: Forces & interactions
PS 3: Energy
PS 4: Waves & their applications in technologies for information transfer

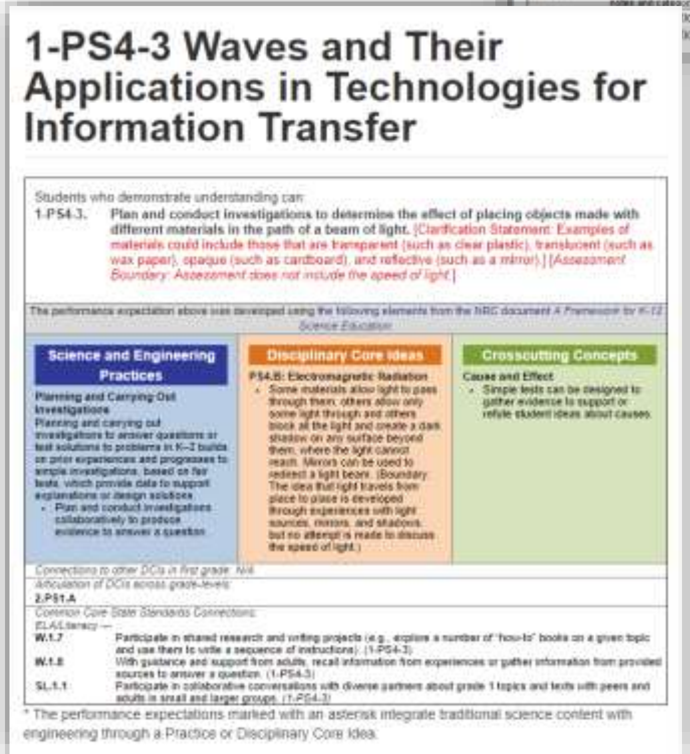
Life Sciences
LS 1: From mole les to organisms: structures & p s
LS 2: Ecos actions, energy, &
LS 3: Heredi ance & variation of t
LS 4: Biolog tion: Unity & diversity

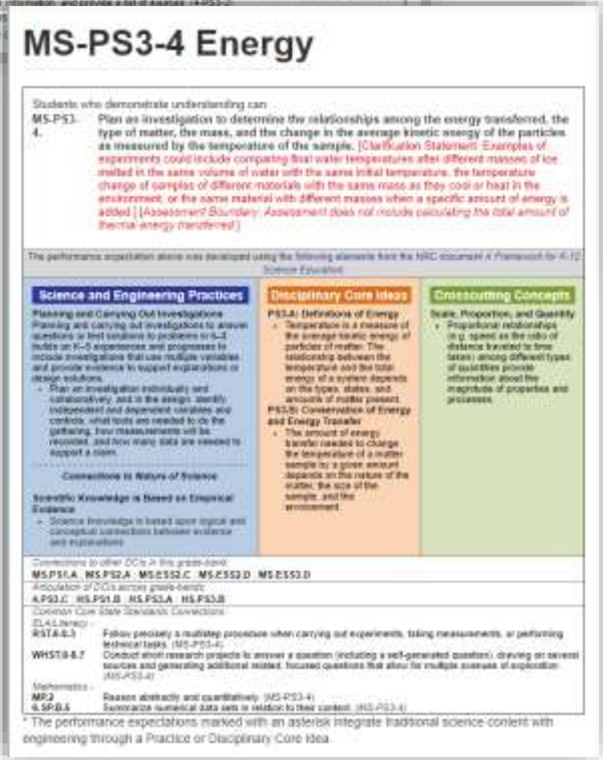
Earth & Spa es
ESS 1: Earth the universe
ESS 2: Earth s
ESS 3: Earth activity

Engineering, Technology, & the Application of Science
ETS 1: Engineering design
ETS 2: Links among engineering, technology, science, & society









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Disciplinary Core Ideas
Crosscutting Concepts
Practices

Disciplinary Core Ideas

Physical Science

PS 1: Matter & its interactions
PS 2: Motion & stability: Forces & interactions
PS 3: Energy
PS 4: Waves & their applications in technologies for information transfer

Life Sciences

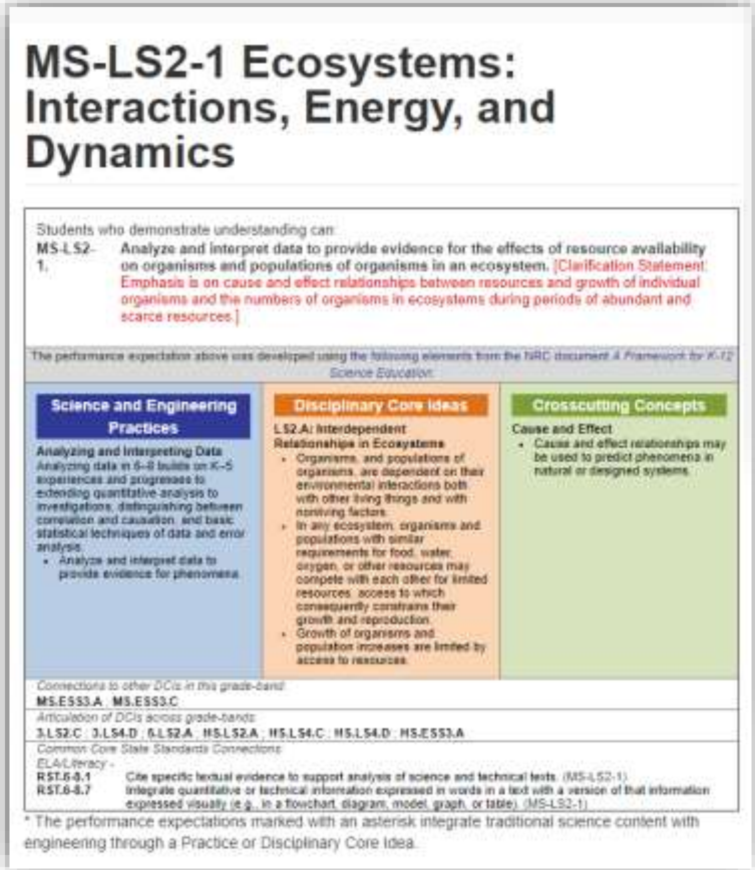
LS 1: From molecules to organisms: structures & processes
LS 2: Ecosystems: Interactions, energy, & dynamics
LS 3: Heredity: Inheritance & variation of traits
LS 4: Biological evaluation: Unity & diversity

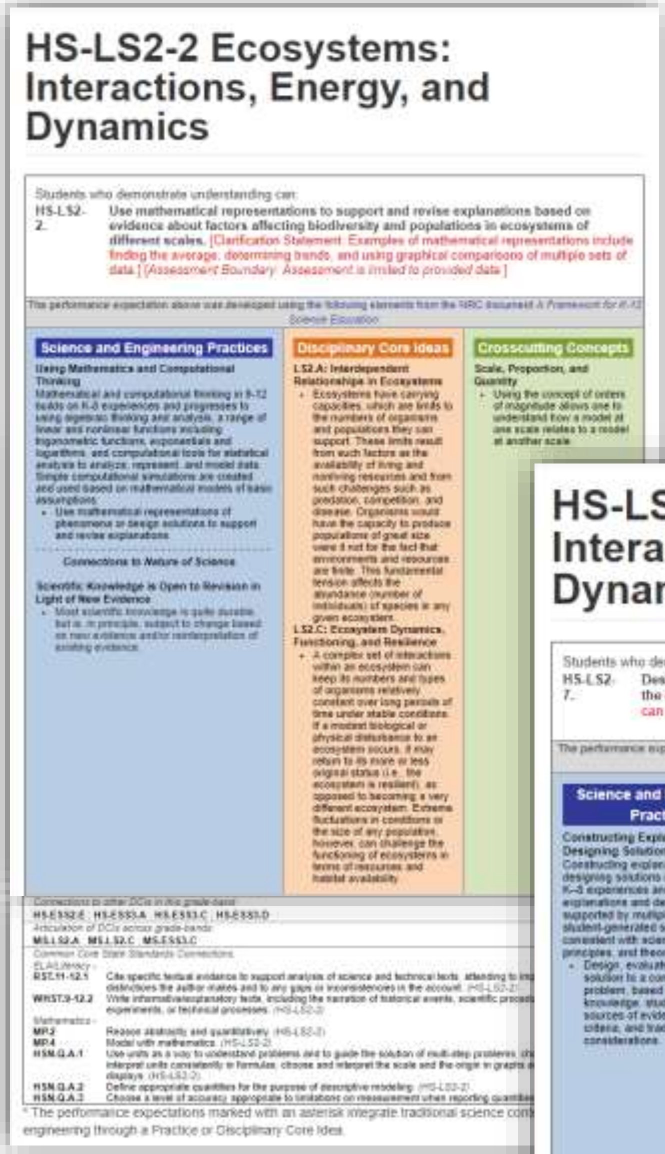
Earth & Space Sciences

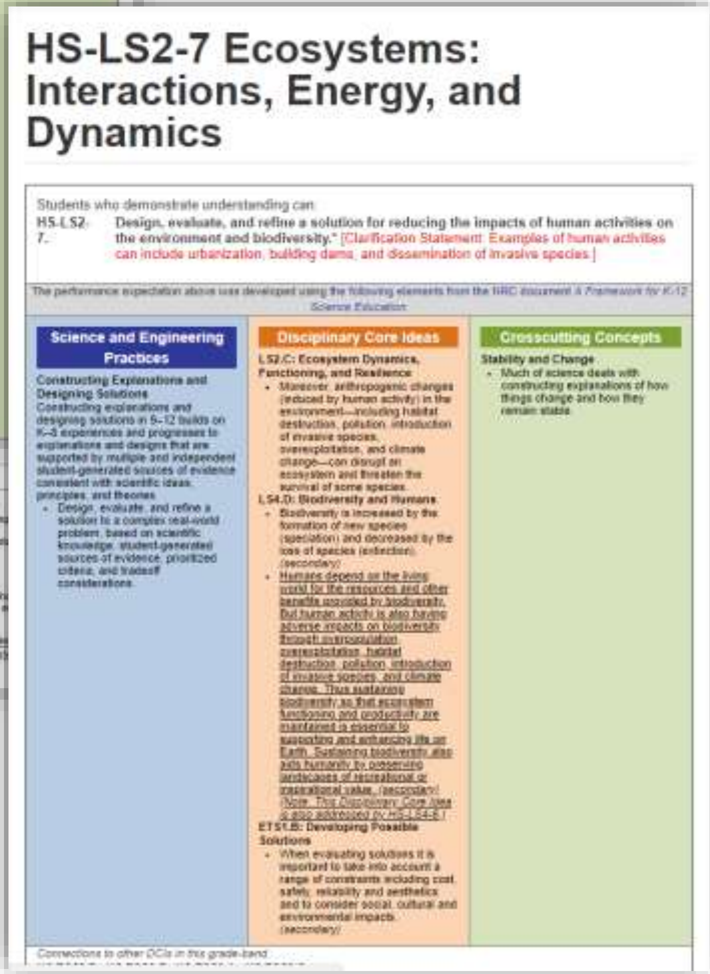
ESS 1: Earth's ... in the universe
ESS 2: Ea...
ESS 3: ...ivity

Engineering ...ogy, & the Application ...e

ETS 1: Engi...sign
ETS 2: Link... ngineering, technology, ... society







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Disciplinary Core Ideas
Crosscutting Concepts
Practices

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LS 2: Ecosys ... eractions, energy, & dy...
LS 3: He... e & variation of ...
LS 4: Biologic... ation: Unity & diversity

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ESS 1: Earth's place in the universe
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ESS 3: Earth & human activity

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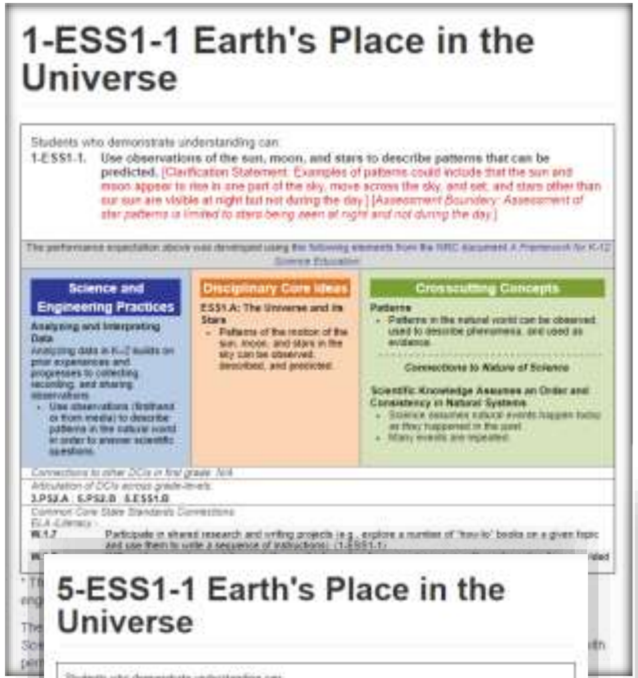

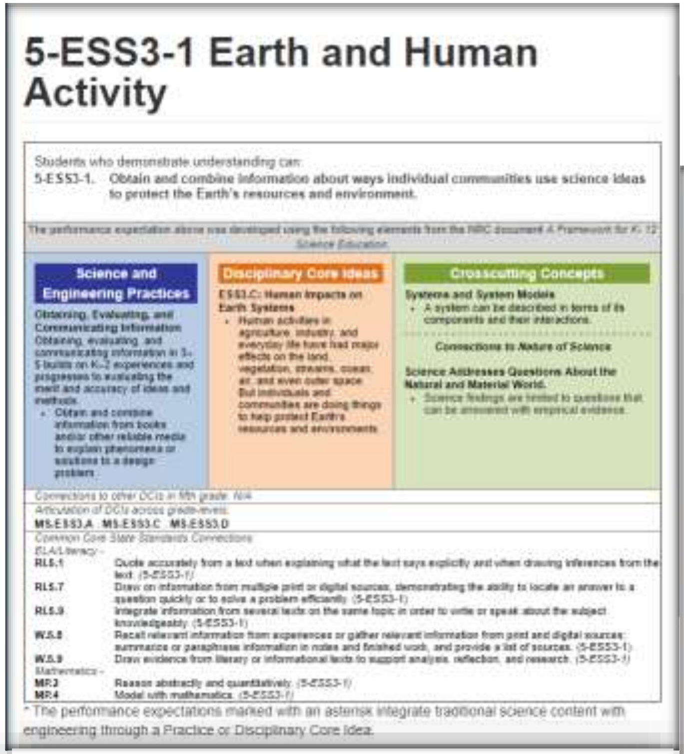

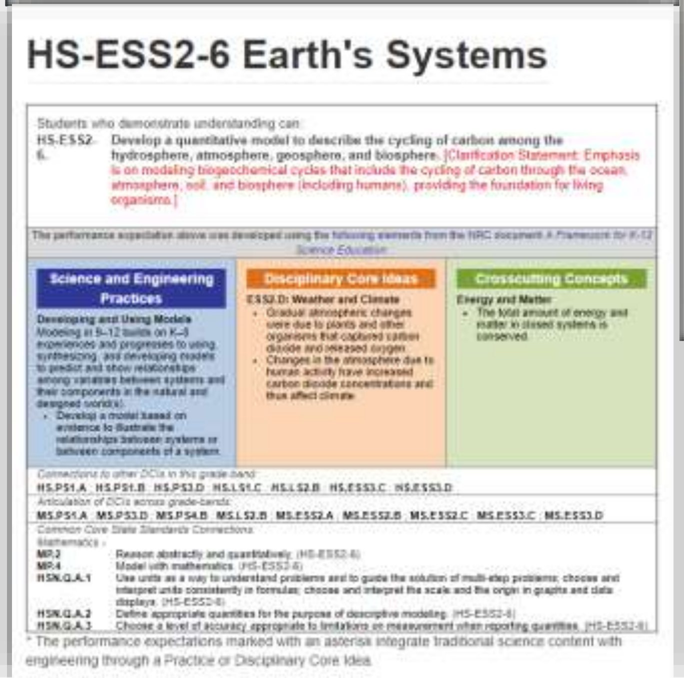

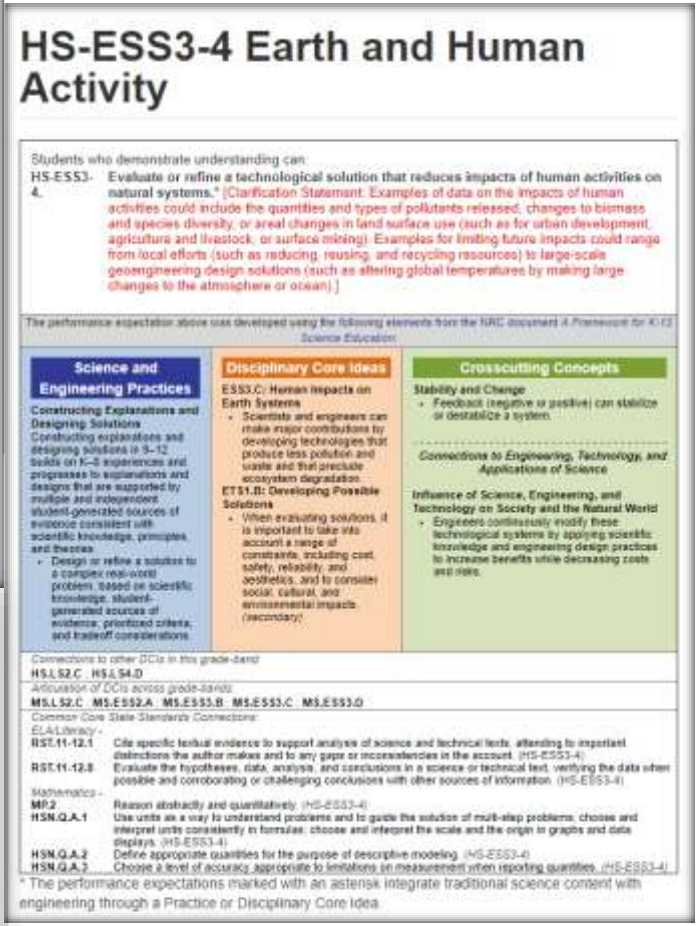

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Disciplinary Core Ideas
Crosscutting Concepts
Practices

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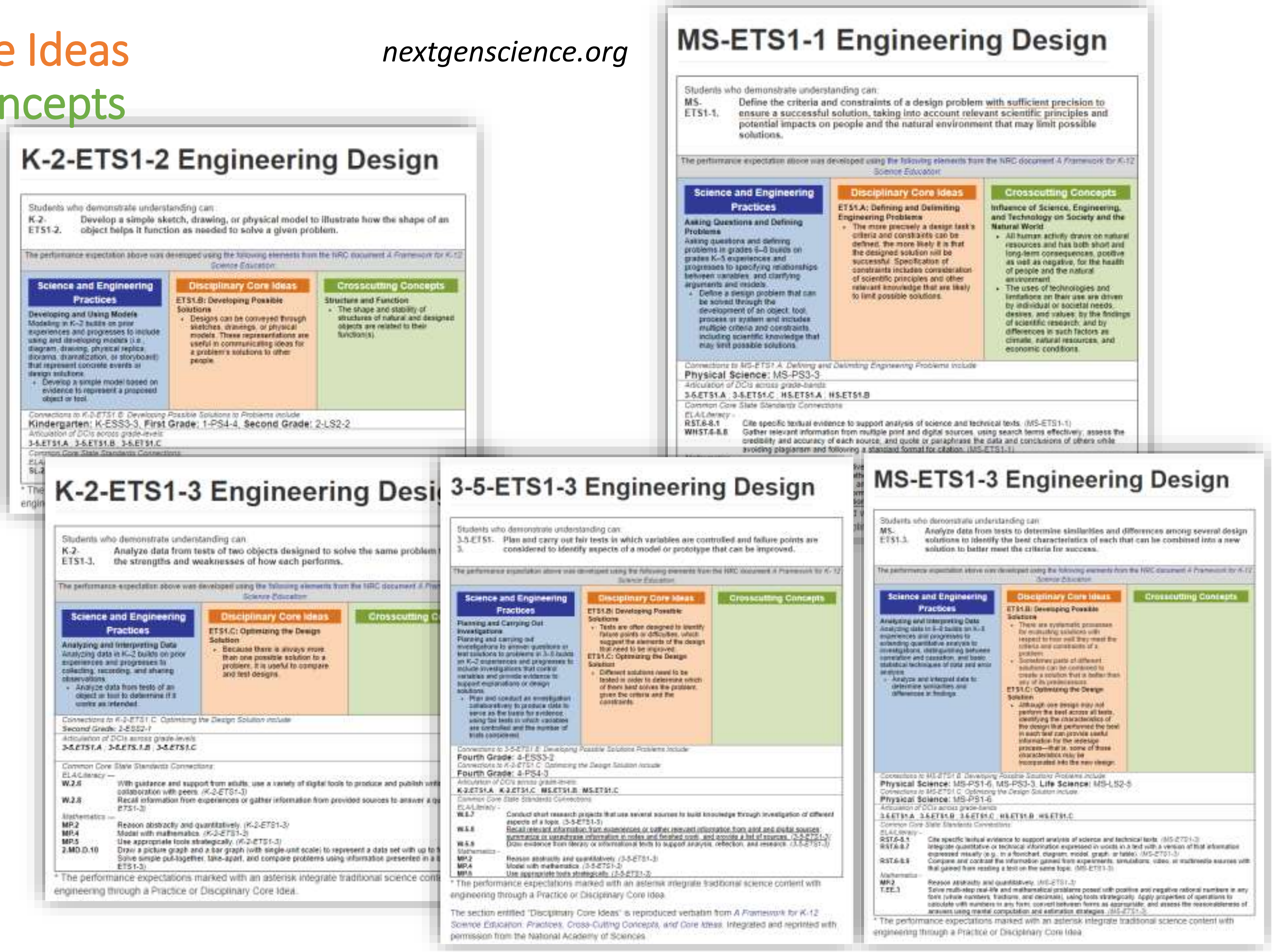


Solar oven themed lessons in practice

INTRODUCE SOLAR COOKING AS AN ENGINEERING DESIGN CHALLENGE

Technology Should Serve Humanity, Not the Other Way Around.

Tim Cook

Identify Problem or Need

Researchers at the Polar Environment Atmospheric Research Laboratory in the Arctic Circle on Ellesmere Island, Canada want to conserve and reduce cooking fuel. It is difficult to transport this fuel to the Research Lab. Researchers also want to reduce the pollutants they are releasing into the air in this environment.

Design Brief

Statement

With your team, design a solar oven model for use at the Polar Environment Atmospheric Research Laboratory. Label how the oven is designed to direct sunlight, absorb sunlight and convert to heat, and retain heat. Remember DARE (Direct, Absorb, Retain, Eat)

Specifications

The oven must utilize reflectivity to gain as much sunlight as possible at low angle.

The oven must include an insulated cooking space so it does not lose thermal energy to the outside.

The oven must cook at temperatures that are safe for food.

The oven must be made of materials that are durable and sturdy.

The oven must withstand windy days and occasional wind gusts.

Identify Problem or Need

Natural disasters can knock out power to a home and community for days and even weeks. Without power, food cannot be refrigerated or cooked using a conventional indoor stove. People may need to rely on dried goods such as rice, beans, and root vegetables.

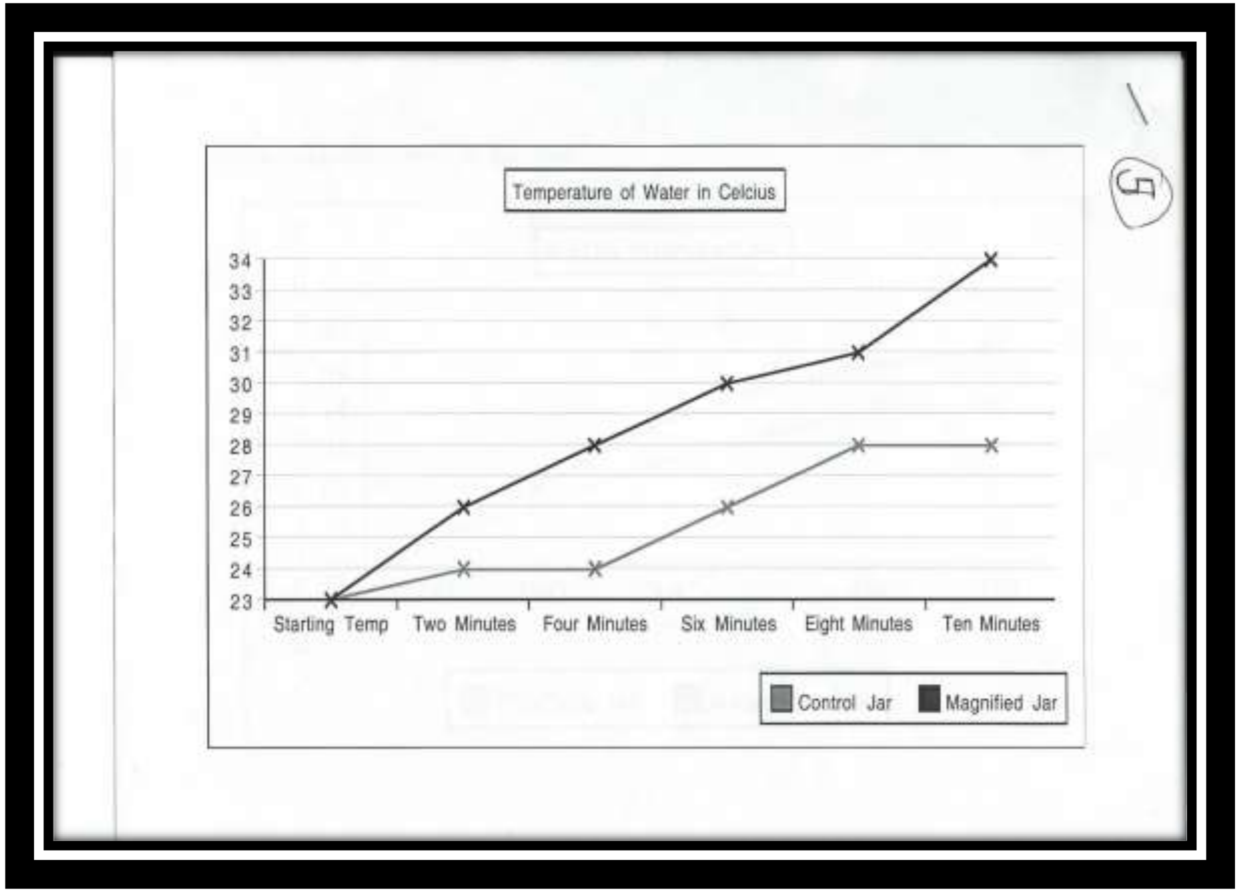
Identify Problem or Need

A church in Haiti cooks daily for about 50 school children. The church would like to learn to use solar ovens to reduce the money spent on charcoal for cooking. With the money they save, they will buy nutritious food for the children.

Students conduct experiments and participate in class activities that reinforce Disciplinary Core Ideas.

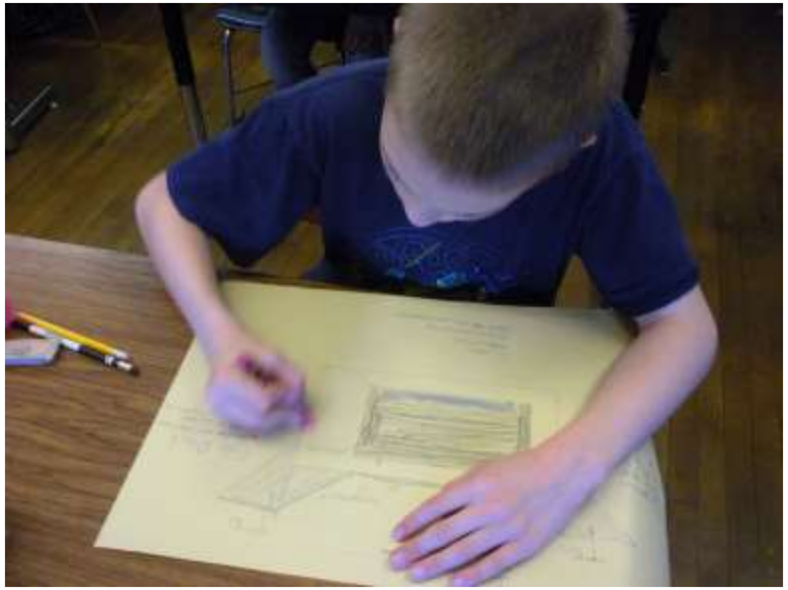
What effect will focusing light on a penny inside a jar of water have on the temperature of the water?

(This experiment and more can be found at GDSnonprofit.org/education)



RESEARCH
DESIGN
COLLABORATE

Students use Disciplinary Core Ideas as the basis for Engineering Design.



SCIENCE AND ENGINEERING PRACTICES

Build a prototype that is your team's solution to the problem.

TEST AND EVALUATE

Students conduct temperature and time tests to evaluate ovens. Discuss changes that can be made.

COMMUNICATE SOLUTIONS

Students discuss solar oven construction with each other, other classes, and adults. Write ideas in science journals.

Representative from the office of Congressman Tim Ryan.

ASSESS IN WAYS CONSISTENT WITH STANDARDIZED TESTING

33) **Standard, Physical Science 2**

In tropical locations, the roofs of homes are often painted white to prevent the temperatures inside the home from getting too hot.

Which statement explains how white roofs keep the temperatures lower inside homes?

Ⓐ The white paint reflects the sunlight.

Ⓑ Sunlight refracts through the white paint.

Ⓒ Sunlight is absorbed and trapped in the white paint.

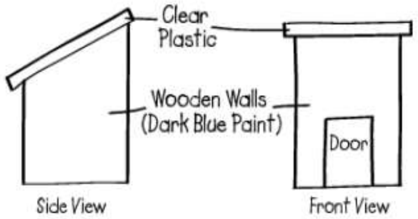
Ⓓ The white paint allows sunlight to travel through the roof.

32.) **St**

A teacher asks his students to design a dog house choosing from the following materials:

- White paint
- Dark blue paint
- Black paint
- Large sheets of aluminum metal
- Wooden boards
- Clear plastic

A student makes a sketch of the dog house.



The student's teacher tells her that the dog house she designed is not safe for a dog. The temperature inside the dog house would become too warm in the summer.

Identify one change she could make to the design of the dog house to keep the inside cooler.

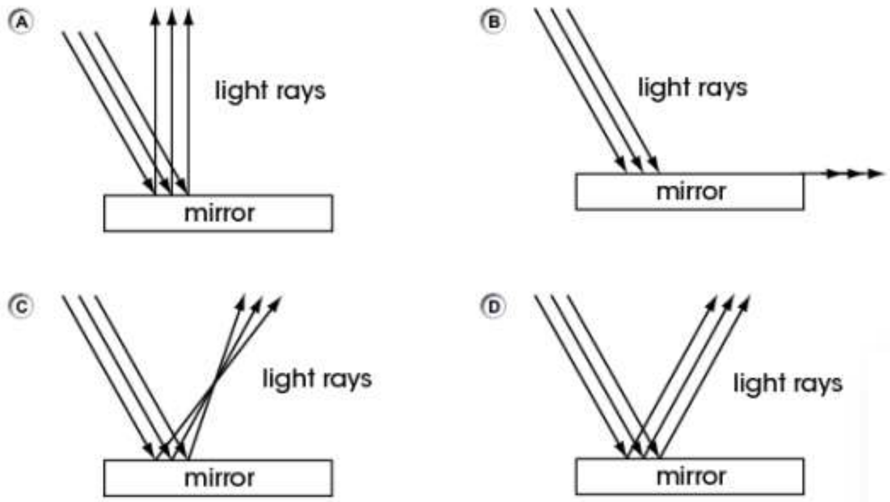
Then, explain how that change would make the dog house cooler in the summertime.

Type your answer in the space provided.

These sample questions from a state standardized test demonstrate how a solar cooking themed lesson can prepare students to understand related concepts.

38) **Standard, Physical Science 2**

Which diagram correctly shows the reflection of light from a smooth, flat mirror?

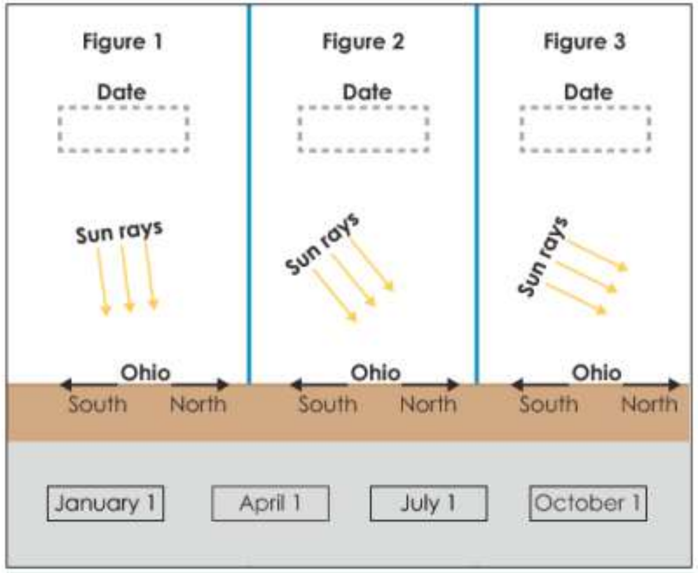


53) **Standard, Earth and Space Science 3**

The figures show the sun's rays shining on Earth's surface in Ohio. Figures 1, 2 and 3 show the same time of day, but on different dates.

Move a date label into each blank box to show the possible dates for the three figures.

- Move only **one** label into each blank box.
- There may be more than one correct answer.
- You do **not** need to use all the labels.



These sample questions from a state standardized test demonstrate how a solar cooking themed lesson can prepare students to understand related concepts.

The need for teaching skills
in a relevant context
is universal.

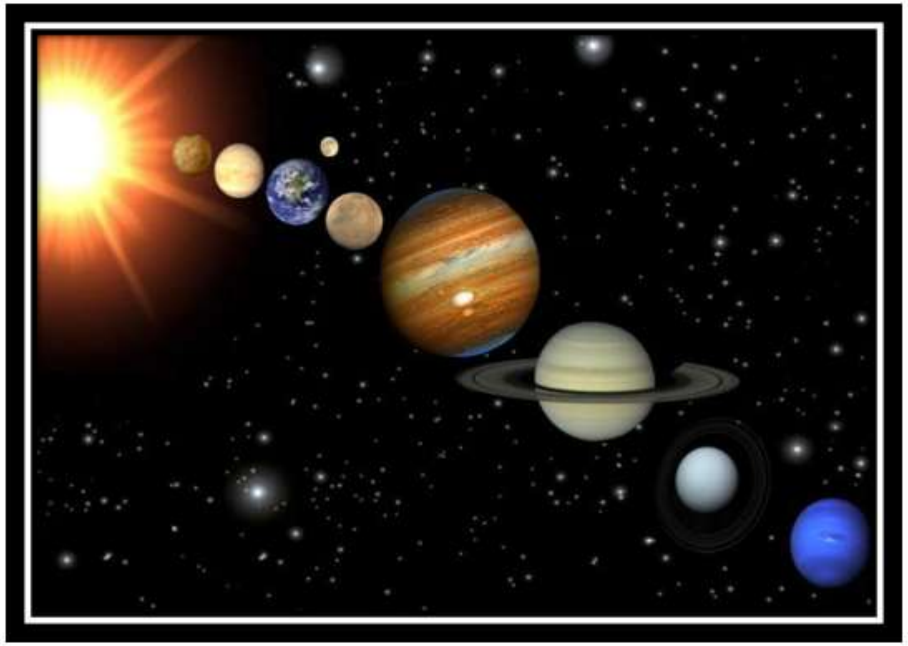
Examples of solar cookers as
tools for STEM education
here and abroad.

Solèy la Etonan

Amazing Sun

Solèy la se yon etwal. Li se nan sant la nan sistèm solè nou an. Planèt yo, ki gen ladan Latè, gravity alantou solèy la.

The sun is a star. It is the center of our solar system. Planets, including Earth, revolve around the sun.



Latè planèt nou an se planèt la twazyèm soti nan solèy la.

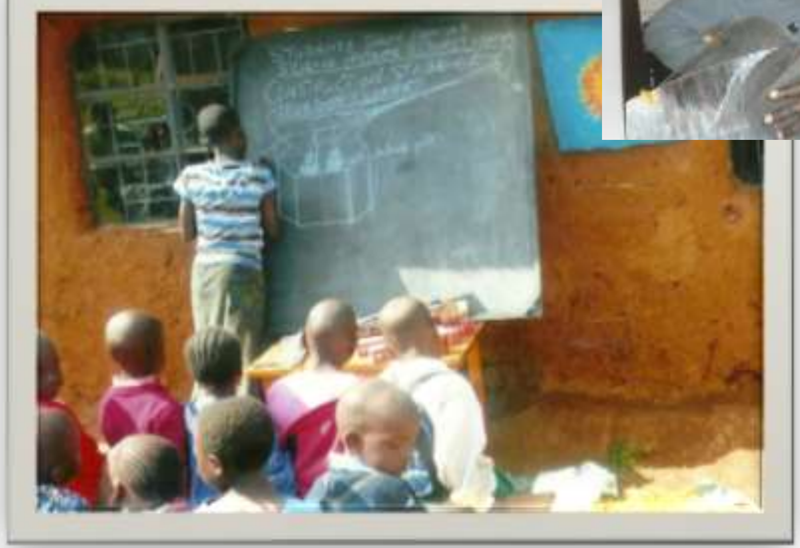
Nou se 150 milyon kilomèt soti nan solèy la.

Our planet earth is the third planet from the sun. We are 150 million kilometers away from the sun.

2

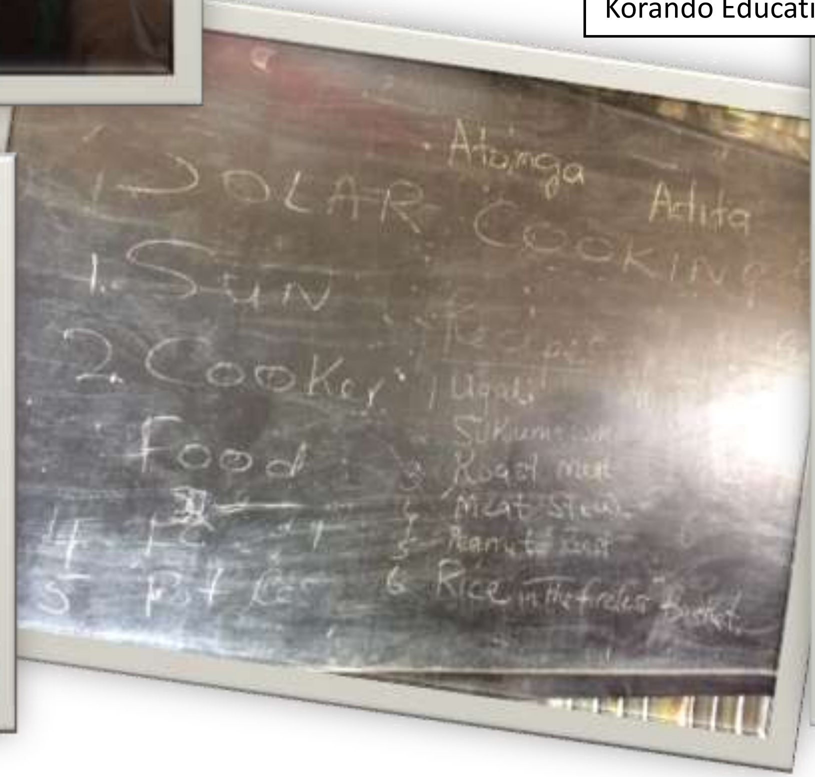
Teaching about solar cooking concepts in Haiti at Institucion Mere Delia with WeCaretoShare.

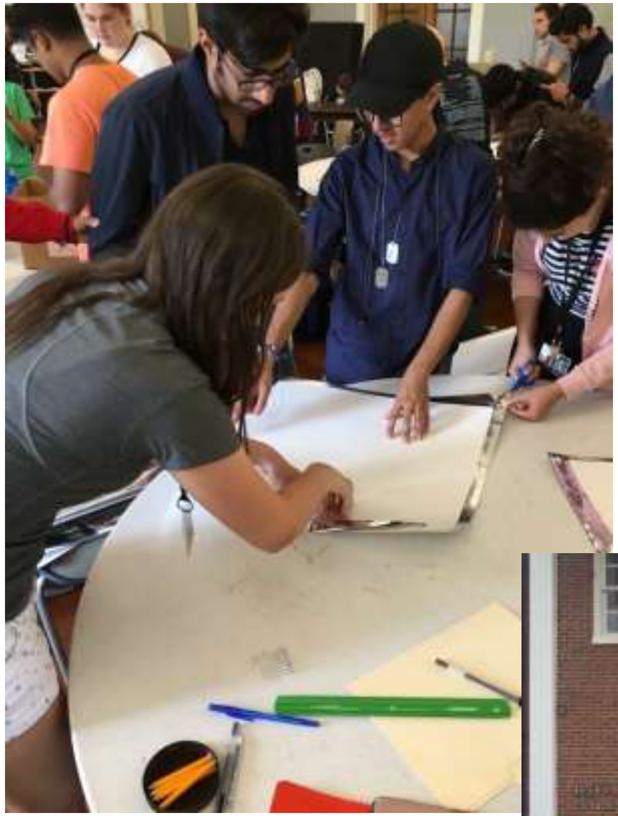
Camily and Gaudenzia Wedende of Eldoret, Kenya, teach children and adults the basic concepts of solar cooking and its many uses with support from Student Solar Cooking Science Projects and GDSnonprofit.



Students at Korando Educational Center in Kisumu, Kenya learn about integrated cooking, including solar, from instructors Faustine Odaba and John Amayo through a GDS sponsored three day workshop.

Students gather round their new SolSource, donated by Hubbard, Ohio Rotary Club, at Korando Educational Center in Kisumu, Kenya. Training program sponsored by GDS.

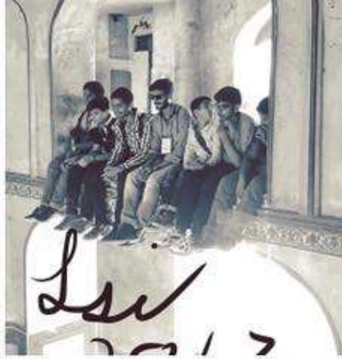


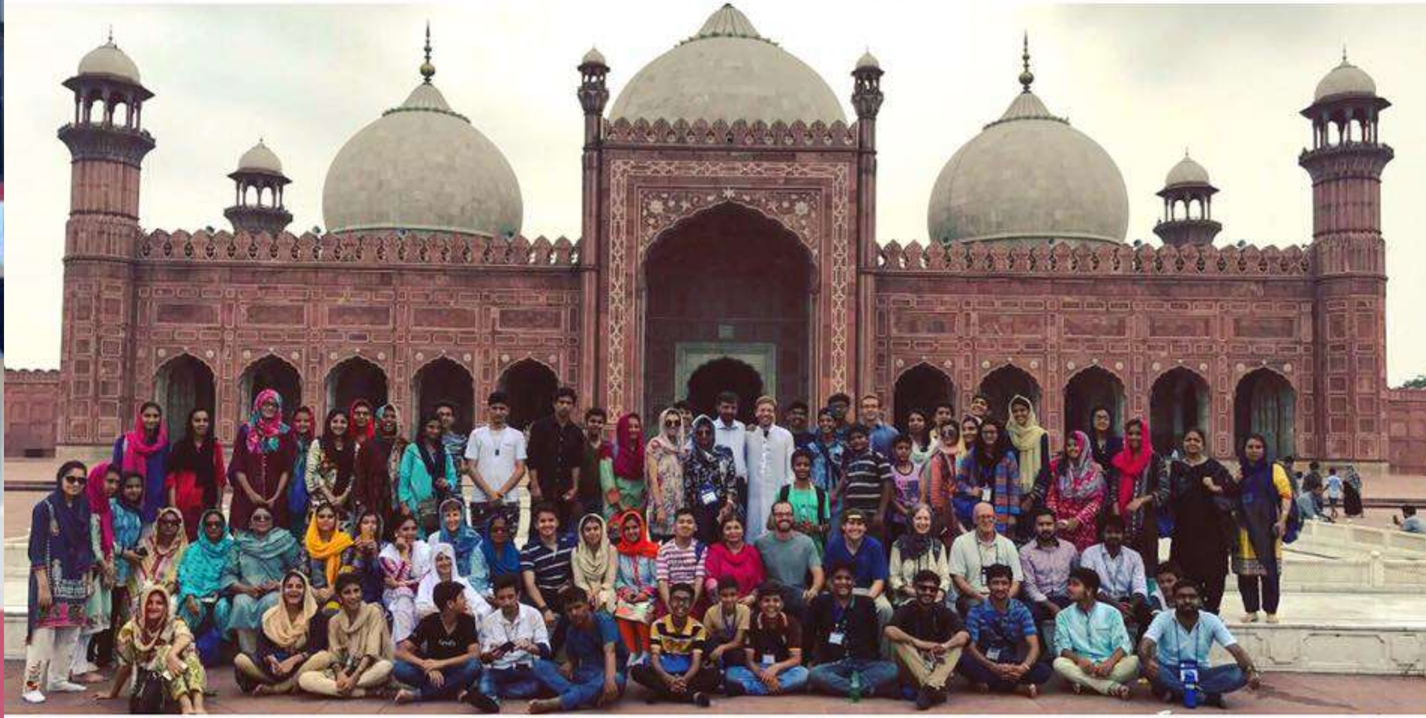


The Solar Sisters, GDSnonprofit conduct workshops on solar cooking for students at Learning Streams International Institute at Hiram College.

Students from USA, Pakistan and Dominican Republic attend.

Teachers and students in Pakistan learn about solar cookers as part of Learning Streams International's ecology education program. Workshop conducted by John Buchenic of GDSnonprofit.








Bethel Business and Community Development Centre
is a commercial and technical school located in a remote rural district of Lesotho.

Mission

To design and manage innovative learning environments for young people in Lesotho that elicit general engineering skills, business savvy, manual capabilities, applied sciences, systems thinking, leadership and management abilities that address the needs of career and business development in Lesotho.

Photo Credit Ivan Yaholnitsky



PART 2

Susan Schleith and Penny Hall

FLORIDA SOLAR ENERGY CENTER™

Creating Energy Independence

UCF
Stands For Opportunity

Mission: To research and develop energy technologies that enhance Florida's and the nation's economy and environment and to educate the public, students and practitioners on the results.

UCF
Stands For Opportunity

Professional Development for Teachers

Solar Cooker Workshops

- Curriculum – concepts, standards, resources and implementation
- Hands-on, team-driven, problem/project-based

FSEC UCF Stands For Opportunity

Solar Energy Cook-off

Students share their projects

- EnergyWhiz & EnergyWhiz Expo Events
- Demonstration, showcase and competition for student team projects
- Awards in Design, Culinary, Fresh from Florida & WOW

FSEC UCF Stands For Opportunity

Designed and Built by Students

Box Cookers

Designed and Built by Students

Panel Cookers

Designed and Built by Students

Parabolic Cookers

FSEC UCF Stands For Opportunity

Designed and Built by Students

Solar Hybrid & Lens Cookers

Solar Energy Cook-off

Students Solar Cooking

FSEC

UCF
Stands For Opportunity

Students Solar Cooking

FSEC UCF Stands For Opportunity

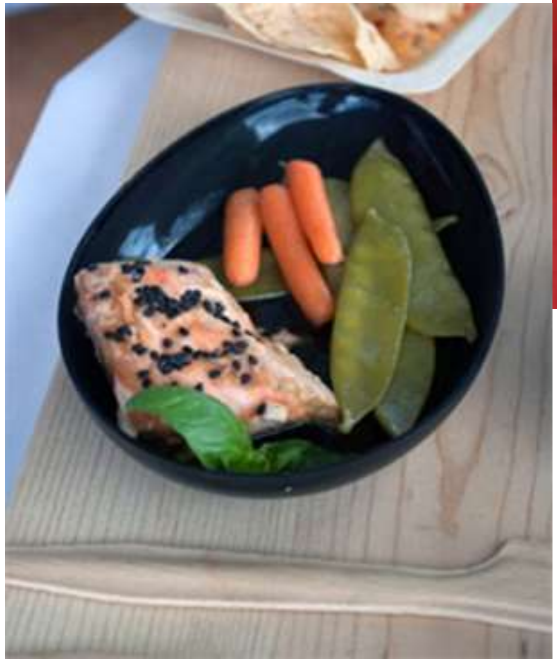
Solar Culinary Arts

Delicious Creations!

FSEC UCF
Stands For Opportunity

Solar Energy Cook-off

Solar Culinary Arts



Fresh From Florida!

FSEC

UCF
Stands For Opportunity

Solar Culinary Arts

More than S'mores!

WOW!


CAUTION
CUIDADO
CAUTION
CUIDADO
CAUTION
DANGER
HARD HAT
PRIVATE
PROPERTY


THE
REBEL'S

Contact Information

Susan T. Schleith - susan@fsec.ucf.edu - 321-638-1017

Penny Hall - penny@fsec.ucf.edu - 321-638-1018

Session powerpoint, cooker plans, curriculum (K-12), cooking tips, recipes & more

http://www.fsec.ucf.edu/download/Education